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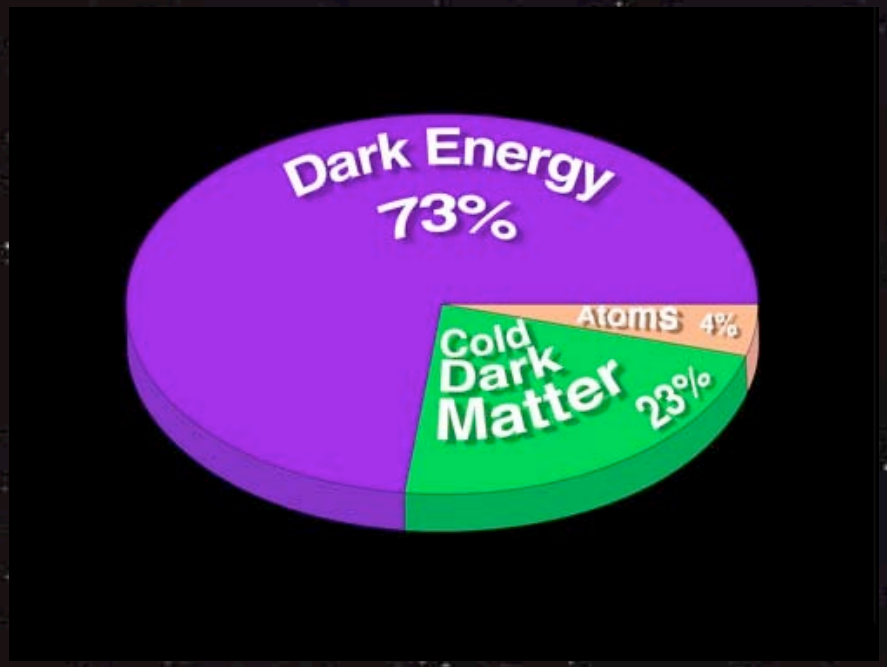
July 10, 2006

CDMS II at Soudan
Back in Operation

- Summary of previous data
- Upgrades installed
- Problems surmounted
- Prospects at Soudan
- The Future - SuperCDMS



Determine nature of cold dark matter

CDMS II in a nutshell
How to detect WIMPS

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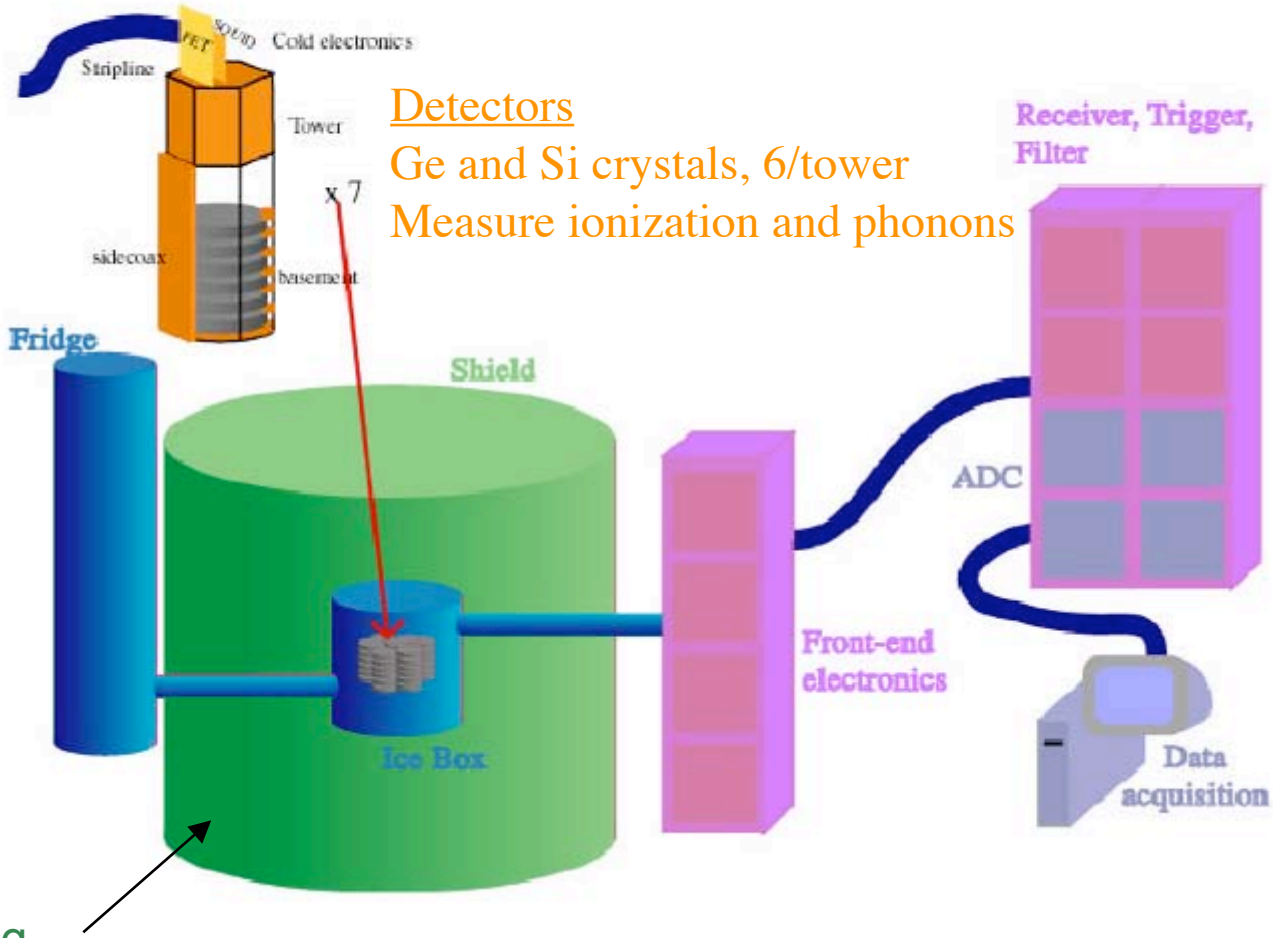

Detectors
Ge and Si crystals, 6/tower
Measure ionization and phonons

Electronics /DAQ
Record signals from detectors and veto; form trigger

Cryogenics
Maintain detectors at 50 mK

Shielding
Layered shielding (Cu, Pb, polyethylene) reduces radioactive backgrounds and active scintillator veto is >99.9% efficient against cosmic rays.

CDMS II Active Background Rejection

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Detectors with excellent event-by-event background rejection

Use charge/phonon AND phonon timing

Measured background rejection still improving!

99.9998% for γ's, 99.79% for β's

Clean nuclear recoil selection with ~ 50% efficiency

Tower of 6 ZIPs

Tower 1

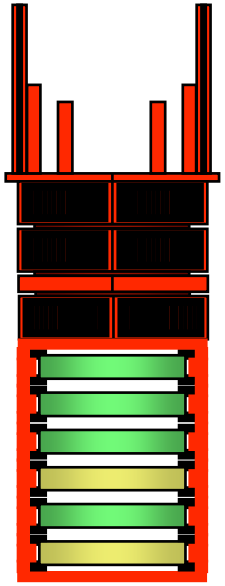
4 Ge

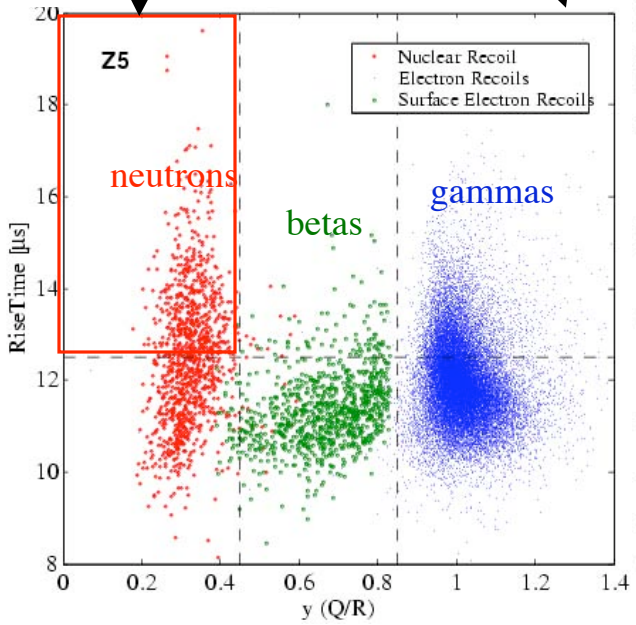
2 Si

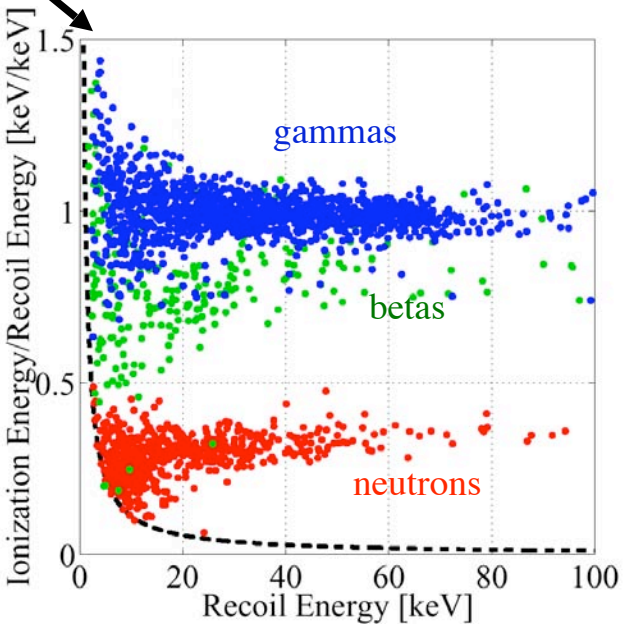
Tower 2

2 Ge

4 Si







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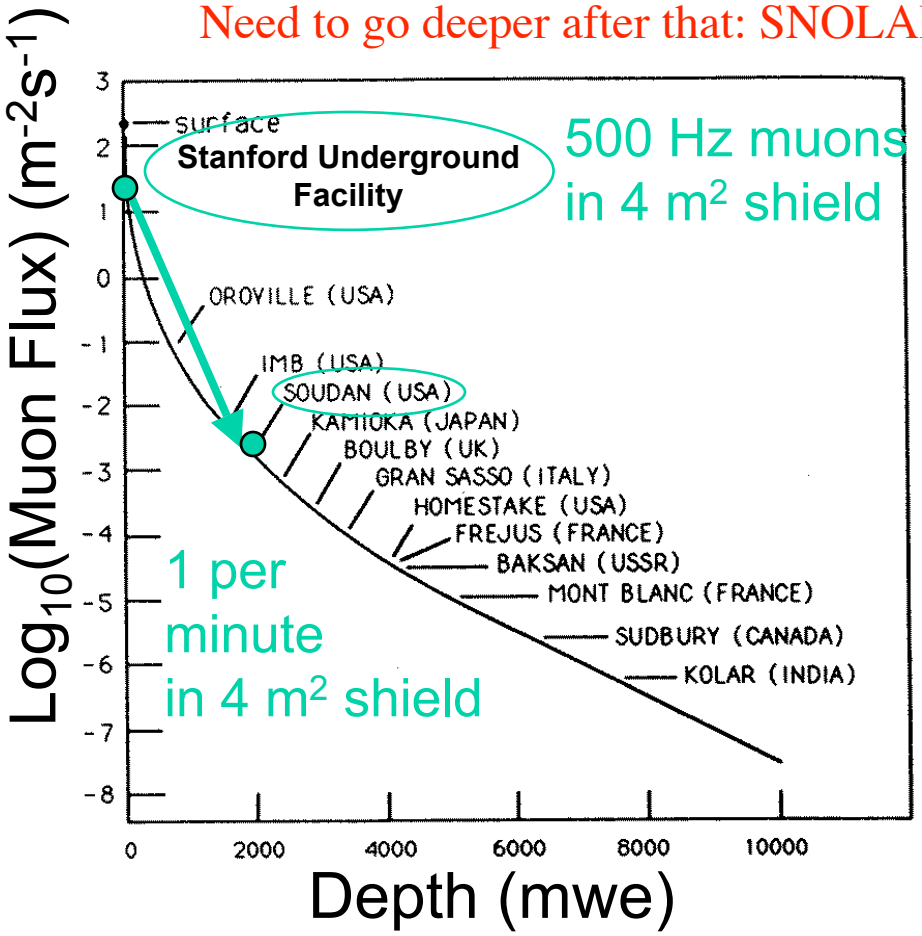
Why are we at Soudan?

Depth of 2000 mwe (2341') reduces cosmic-ray-induced neutron background to < 0.1 / kg / year at Soudan => sensitivity to a few WIMPs per year!

Likely to be the limiting background by ~ 2008

Need to go deeper after that: SNOLAB is 6000 mwe (6800')



First detectors arriving: winter 2003

Full Year of Running CDMS II at Soudan

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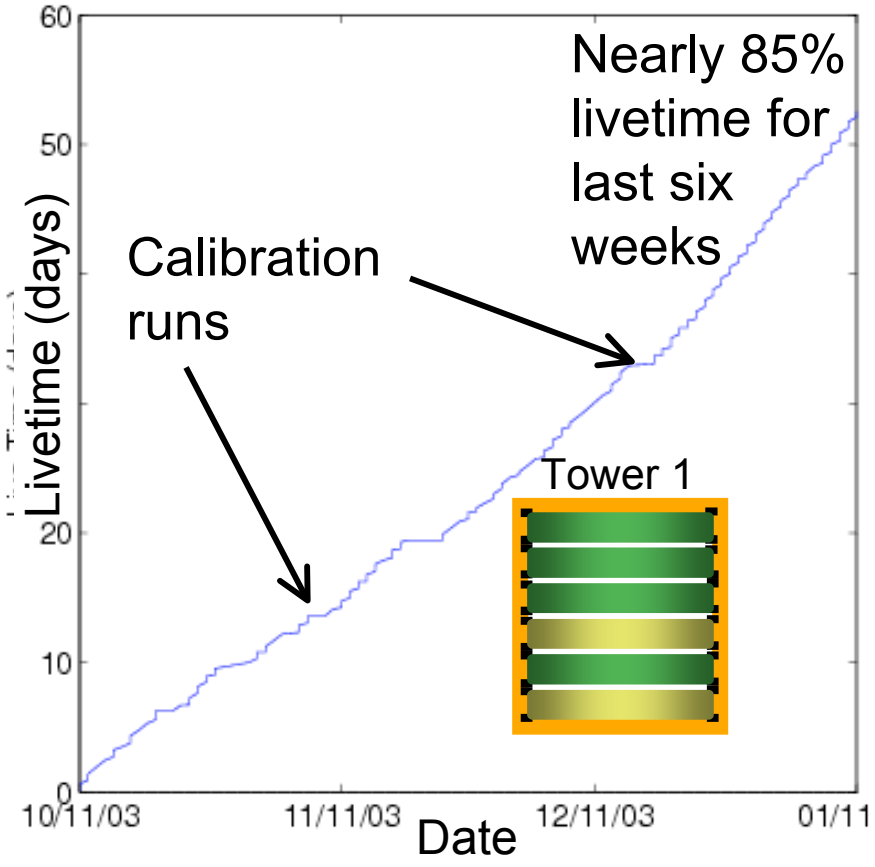
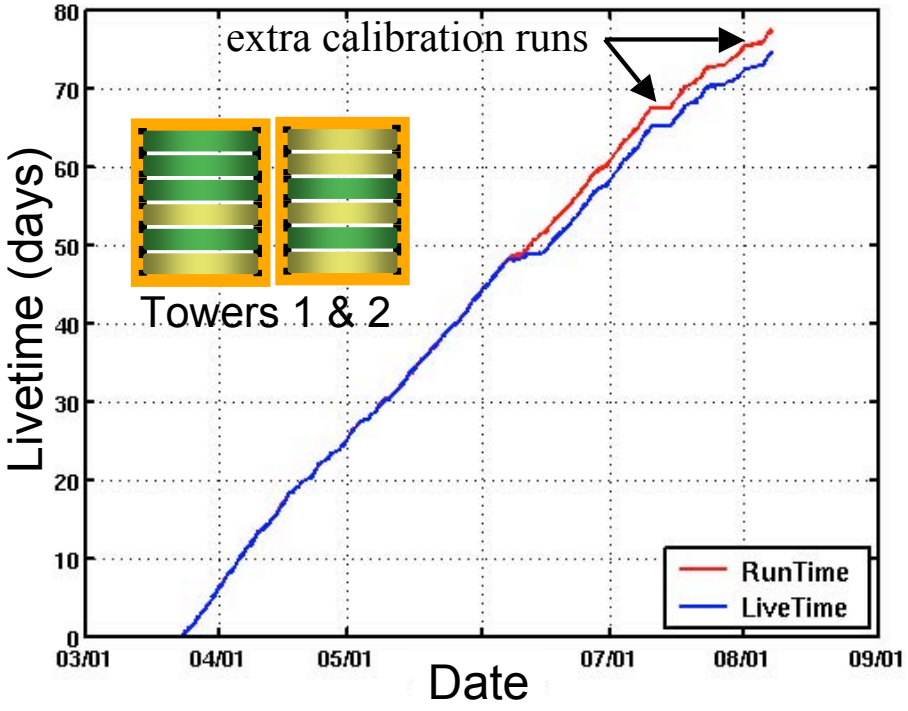
- October 2003- January 2004 "Tower 1"
  - 1 kg of Ge, 0.2 kg of Si
  - 62 "raw" livedays, 53 livedays after cutting times of poor noise, etc.

- March-August 2004 "The Two Towers"
  - 1.5 kg of Ge, 0.6 kg of Si
  - 76 "raw" livedays, 74 livedays
  - Nearly doubled exposure, expected sensitivity, and calibration data



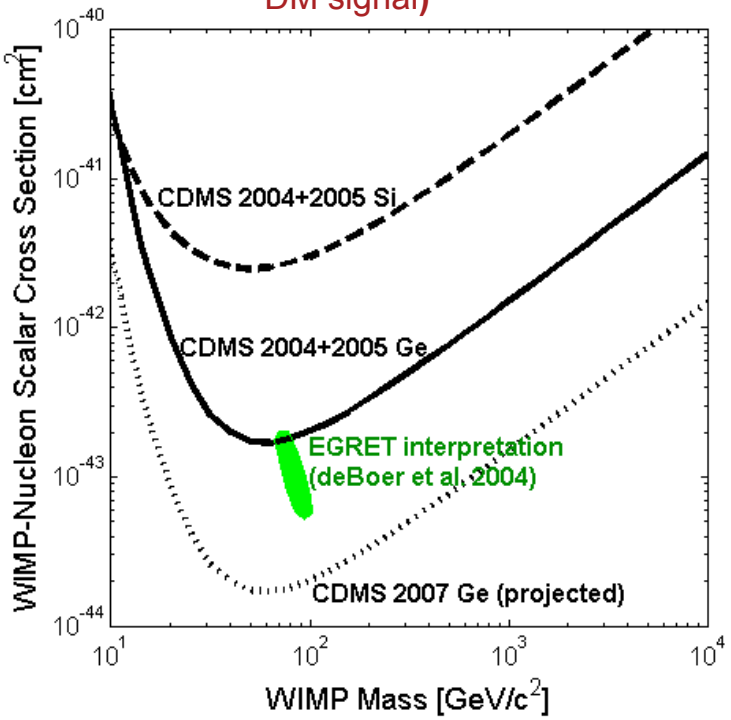
Exposure = Target mass x Livetime
Equivalent to Luminosity for Colliders

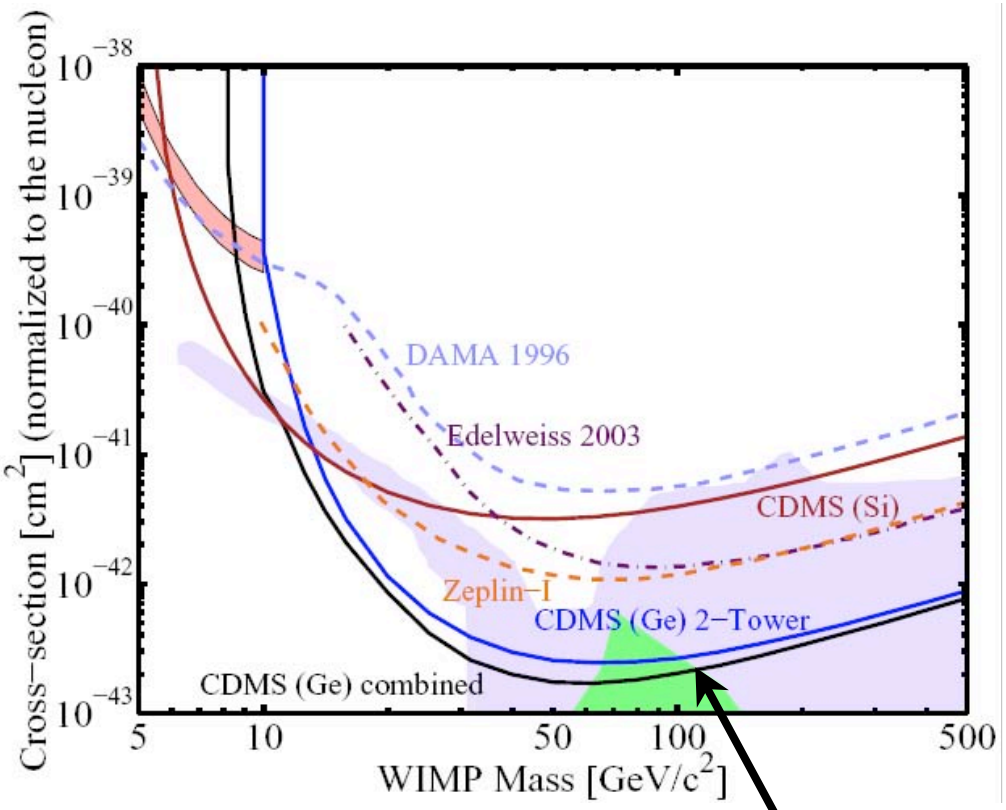


CDMS-II Results for Spin-Independent Interactions

CDMS has the World's Best Limits

DAMA/NaI
Bernabei et al., astro-ph/0307403
(we see no evidence of claimed DM signal)





EGRET
de Boer et al., astro-ph/0412620

- Cannot yet rule out EGRET gamma ray excess as DM annihilation

For further details see PRL 96, 011302 (2006)

Cryogenic and Detector Upgrades

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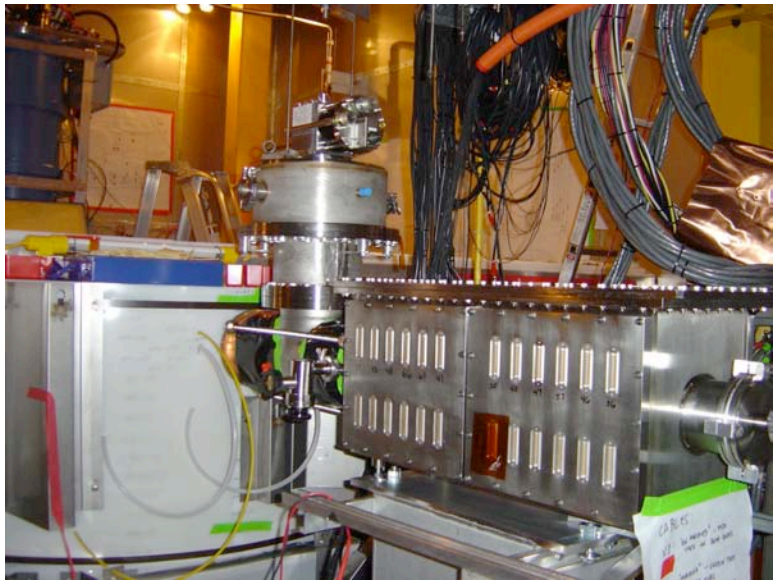
- Cryogenics
  - System worked reliably for 1 year of running at 50 mK!
  - So why did we 'fix' it if it wasn't broken?
    - Better vacuum to improve stability, decrease maintenance
    - Better control and monitoring, more robust against power outages (UPS and generator installed)
    - Improve cooling at 4K with cryocooler on electronics stem; reduce Lhe consumption, costs
- Detectors
  - Three new towers installed in fall of 2004; total of 4.5 kg Ge, 1 kg Si



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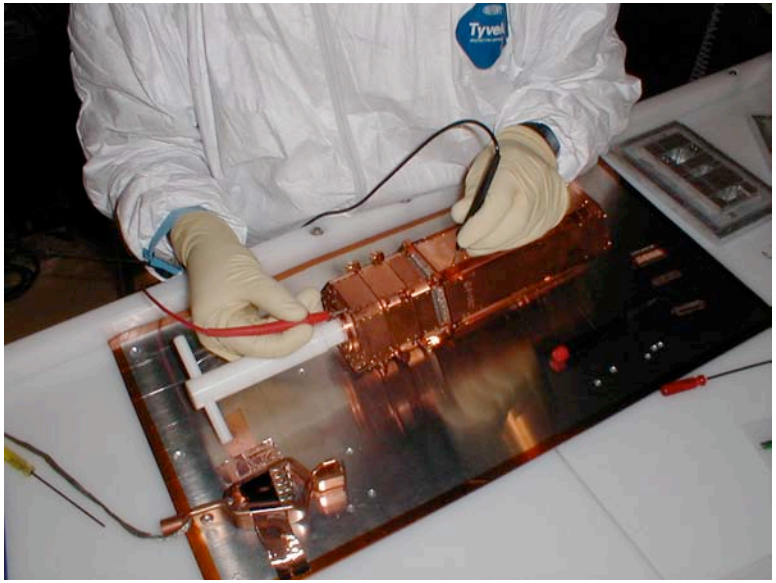
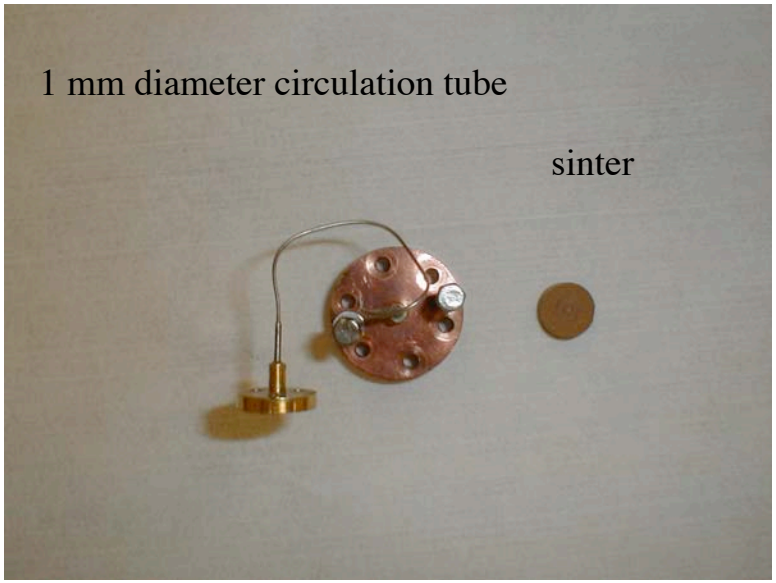
A Series of Unfortunate Events…

- Detector damage (early 2005)
  - Tower wires damaged by thermal shielding
  - Repaired on all good detectors in January 2005
- Vacuum leak near the new cryocooler
  - Found and fixed in February 2005
- Dilution refrigerator blocked (March 2005)
  - Discovered 4 hours before cooldown!
  - Required tedious removal of refrigerator from icebox and disassembly (~ 3 months of work)
  - Culprit was tiny bit of 'sinter' that broke loose and plugged circulation tube
  - Fridge passed 'stand-alone' test
- More leaks (fixed April/May 2005)
  - Helium bath
    - Difficult Indium seal not tightened sufficiently
  - Nitrogen Shield
    - Connectors to icebox cooling loop leak





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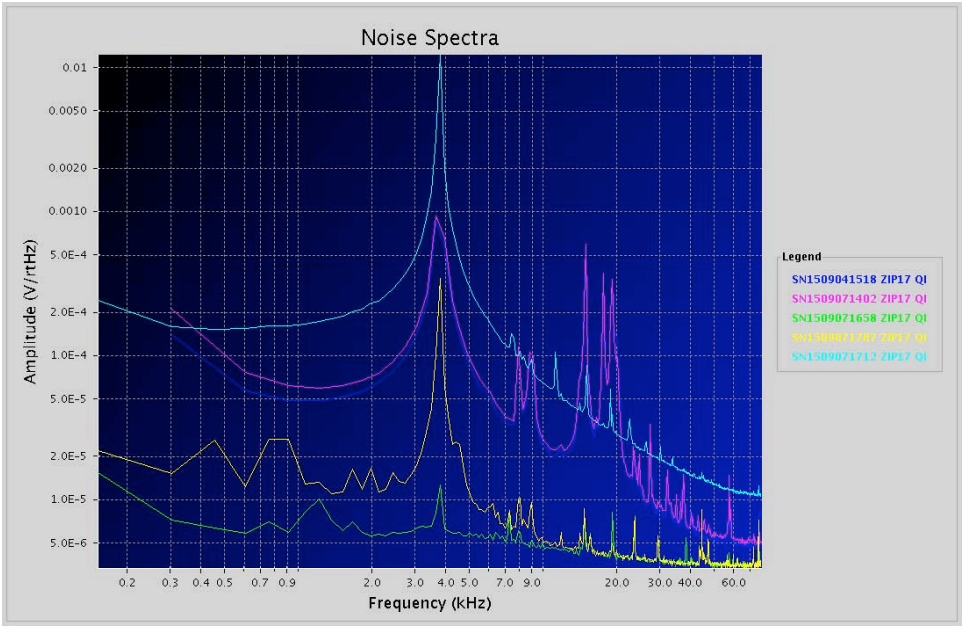
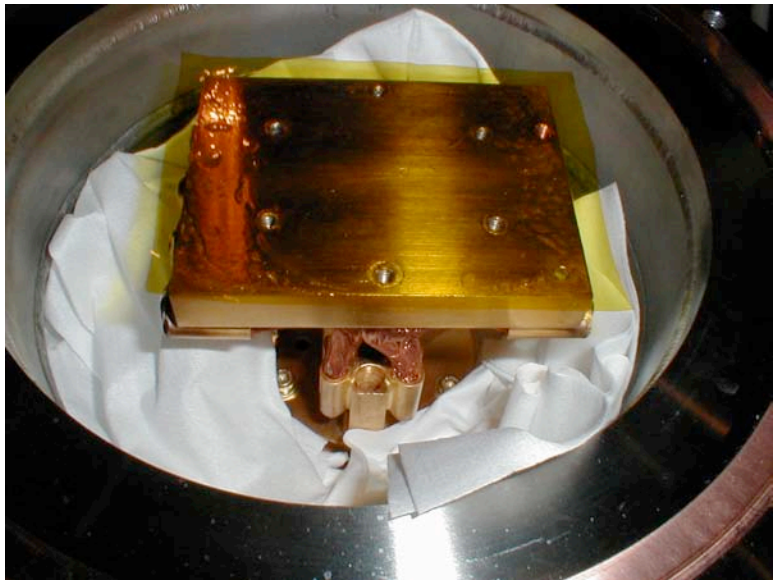
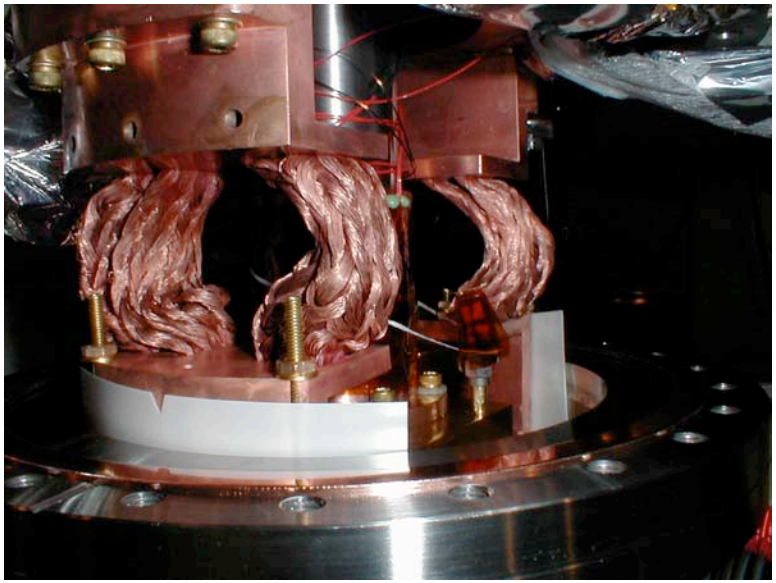
A Series of Unfortunate Events…

- Cryocooler vibration (summer 2005)
  - Induced electrical noise in detectors
  - Vibration isolators for both 77K and 4K stages designed and installed in fall 2005
  - Reduced vibration by x100 by winter 2005







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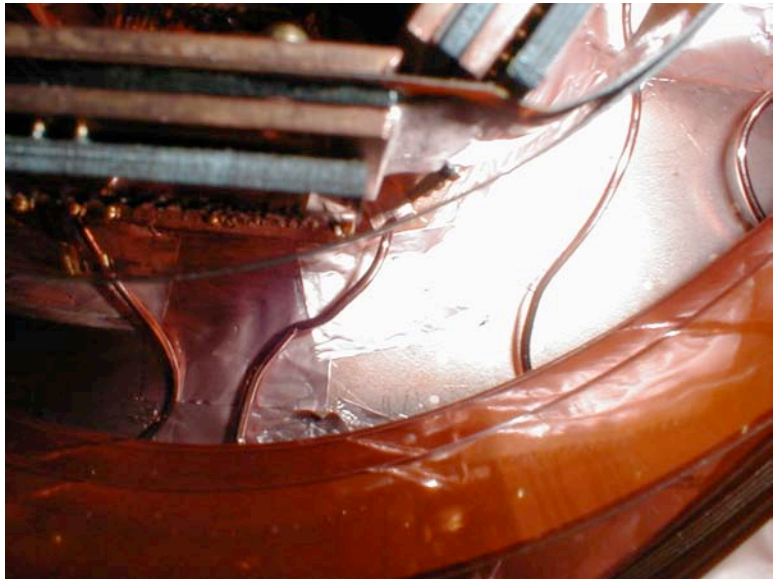
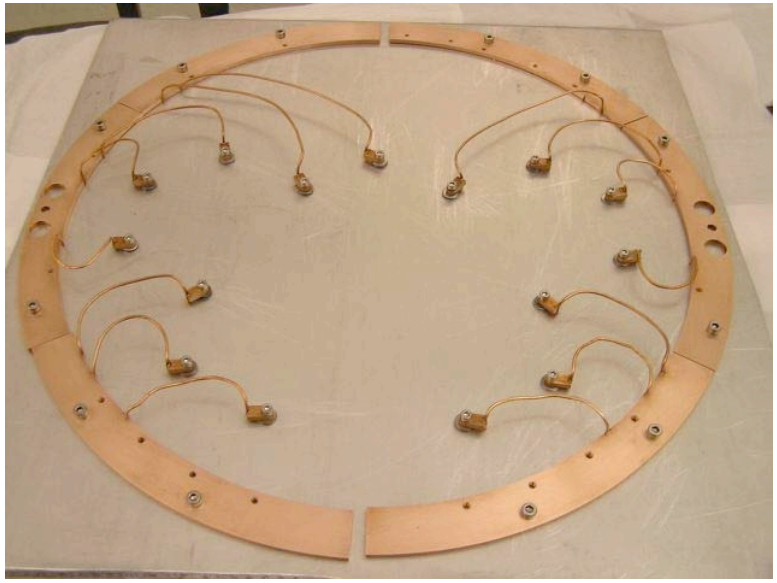
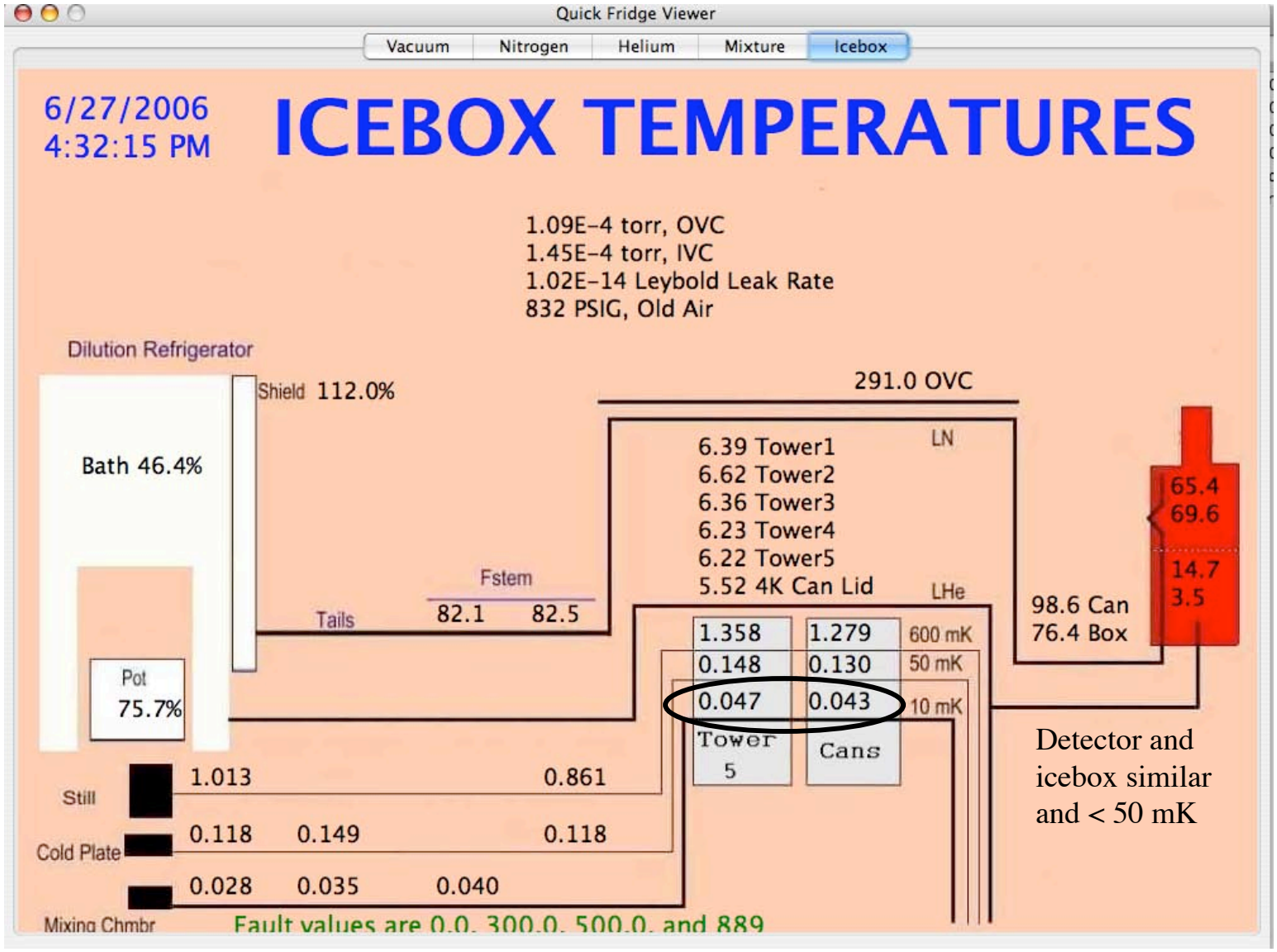
A Series of Unfortunate Events…

- Detectors too warm (winter 2006)
  - Fridge at 25 mK but detectors at 250 mK
    - Need to be ~50 mK for phonon channels to work
  - Realized problem was due to thermal joints
    - Copper oxide developed over time
    - Too much heat conducted down towers to detectors, not enough to fridge
- Improve thermal joints
  - Scotchbrite all thermal connections on towers
  - Install new soft copper heat sink wires
  - Install additional thermometry





Success! Detectors at 47 mK

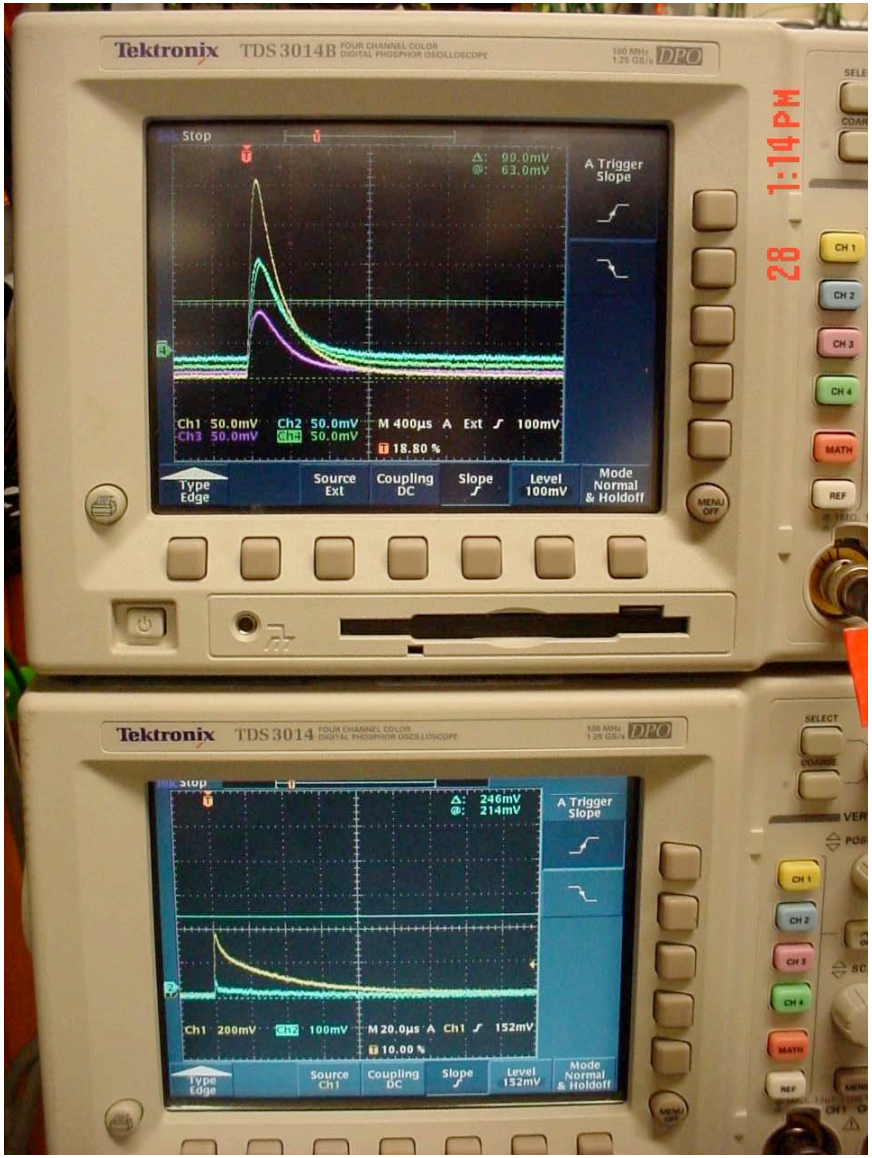


Five Towers Now Operating at Soudan

All detectors showing charge and phonon pulses at 50 mK

29 out of 30 detectors will be used in dark matter search

(1 old Ge still useful as veto)

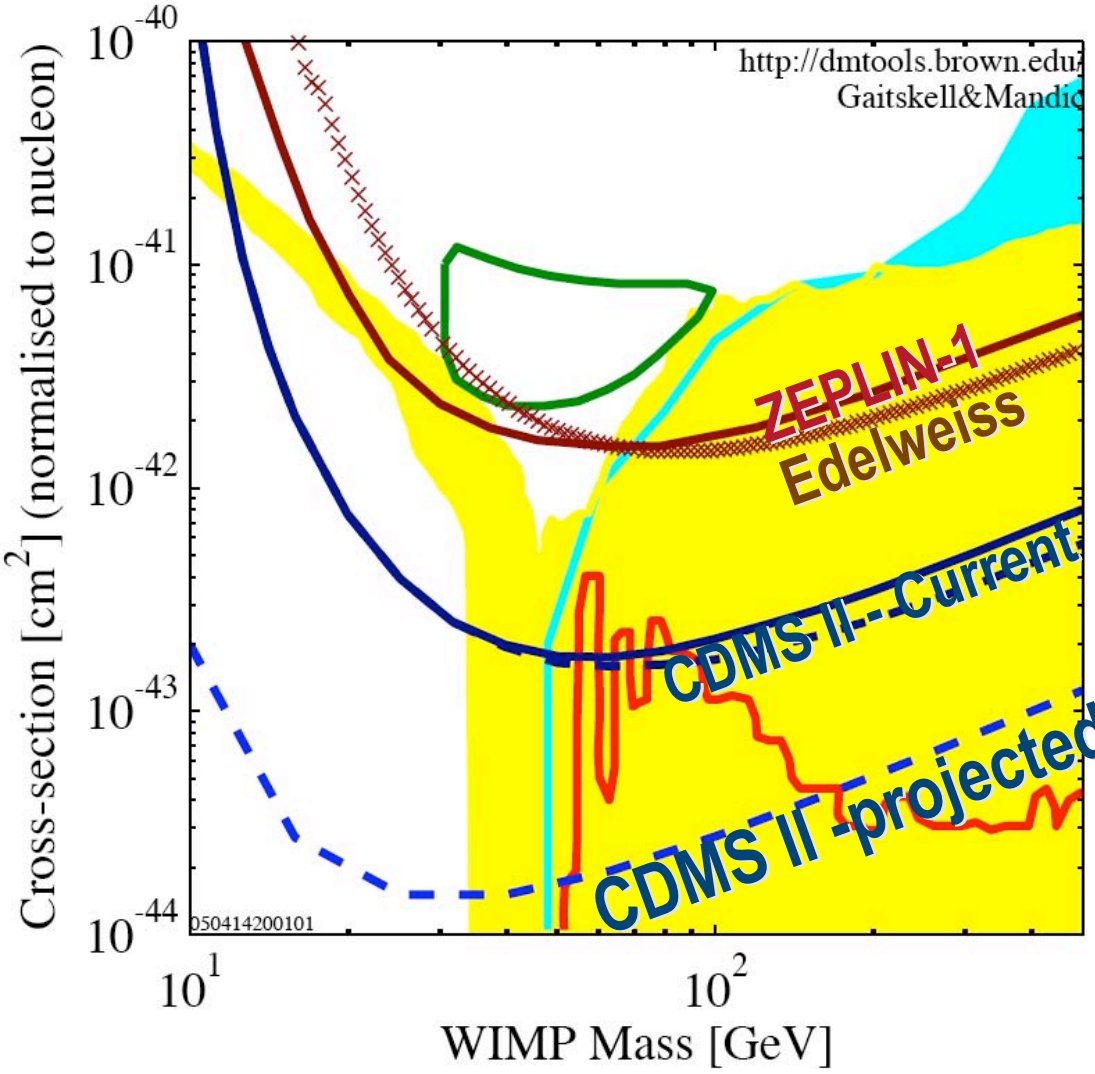


Tower 5 Event

Phonon pulses

Charge pulses

The Future of CDMS at Soudan



Schedule

July 2006

- Detector tuning and calibration
- Restore shield/veto
- Electrical noise reduction

August 2006

- Neutron calibration
- Background measurements
- Final tuneup

September 2006 - December 2007

- WIMP search with five towers

January 2008

- Limits x10 better than current OR maybe a signal!

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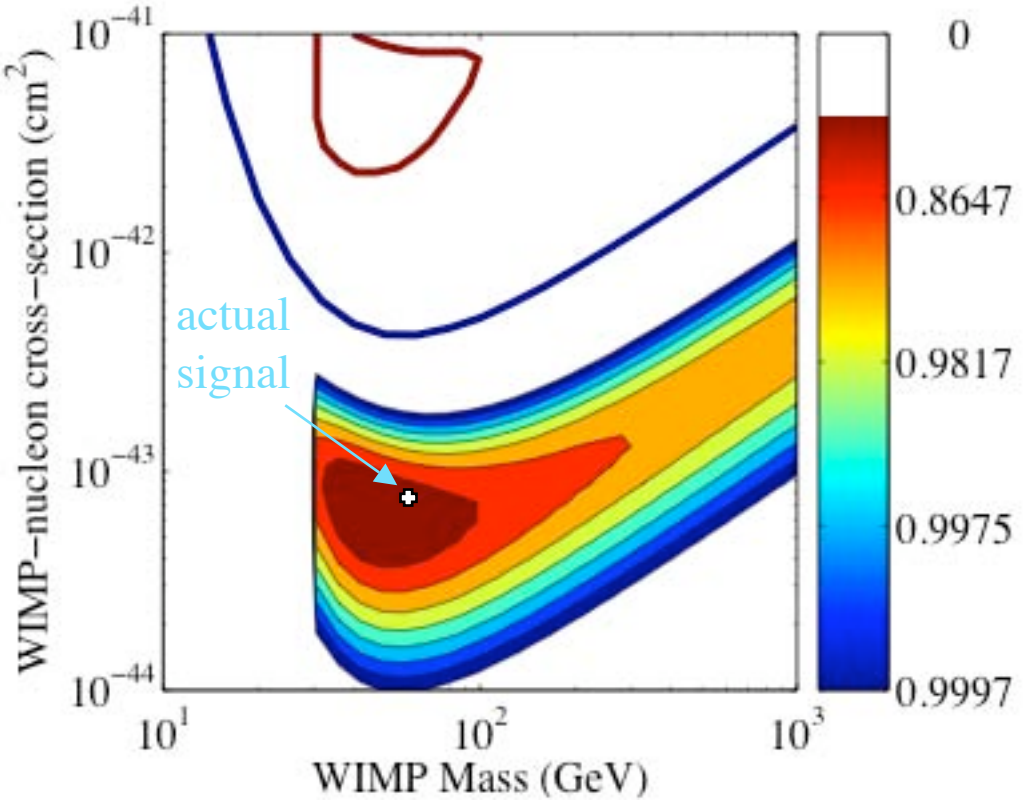
What do we learn if we see a signal?

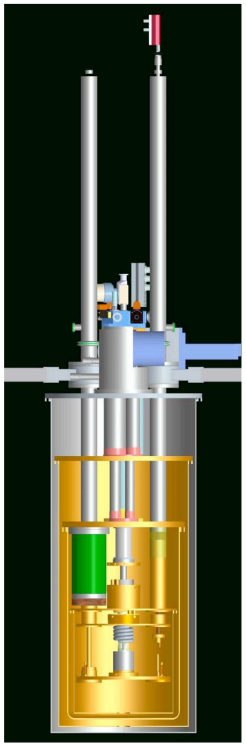
- Current 90% C. L. corresponds to < 1 evt per 8 kg-d for Ge
- Suppose we see 8 events at rate of 1 evt per 50 kg-d
- Then mass & cross section determined as shown and SI vs SD determined from different targets
- Suggest where to look at colliders

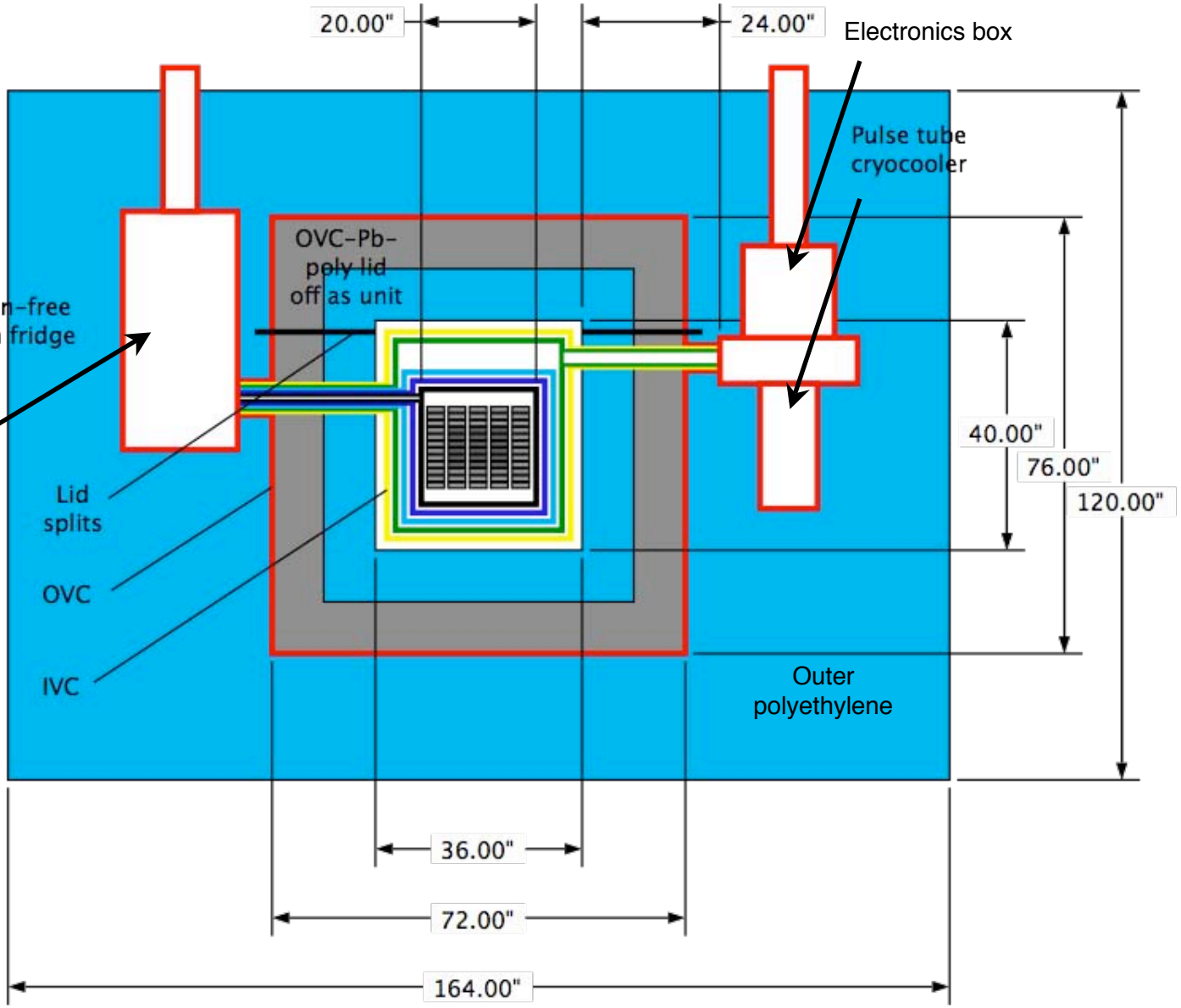


We are proposing x10 more sensitive SuperCDMS 25 kg experiment at SNOLAB to follow up on any hint of signal from CDMS II at Soudan. Complementary reach for MSSM neutralinos with LHC and ILC!

SuperCDMS Cryogenic design at Fermilab

Design robust, cryogenics system that requires less maintenance and operating costs





SuperCDMS Involvement at Fermilab

- Cryogenics
  - Design, Construction, System-test
- Warm electronics
  - Repackaging of front-end, trigger, digitizer functions in modern form
- Shielding and Backgrounds
  - Must reduce backgrounds near detectors
  - Shielding needs to be integrated with cryogenics
- SNOLAB infrastructure
  - Cleanrooms, crane, conventional infrastructure
- Detector testing
  - Exploring FNAL facilities for automated inspection
- Physics analysis
  - Will be LOTS of CDMS II data soon
- NEW collaborators welcome!